EK307 Introduction to the Lab

Learning to Use the Test Equipment

Laboratory Goal: Become familiar with the test equipment in the electronics laboratory (PHO105).

Learning Objectives:

- Voltage source and battery polarity
- Using the multimeter to measure voltage, current, and resistance.
- Using the power supply as a voltage source.

Introduction

In this lab, you will learn how to use the various instruments listed above. We will use these instruments frequently in EK307 labs, so it is important to master them.

A. Measuring Resistance with the Multimeter

Resistors come in all shapes and sizes. In EK 307, we use common axial-lead resistors, like the one shown below to the right. The value a resistor is indicated by three color bands which correspond to a numerical code, summarized at the end of this handout. Most of the resistors the lab have a fourth gold band which indicates a precision of ±5%. That is, the actual value of the resistor may vary by up to 5% above or below the value indicated by the color-band code. The maximum wattage of resistor is determined by its physical size; we use ¼-watt resistors in the lab.

As discussed in lecture, current will flow through a resistor in response to a voltage applied across its terminals. The relationship is described by Ohm's Law: $I = \dfrac{V}{R}$

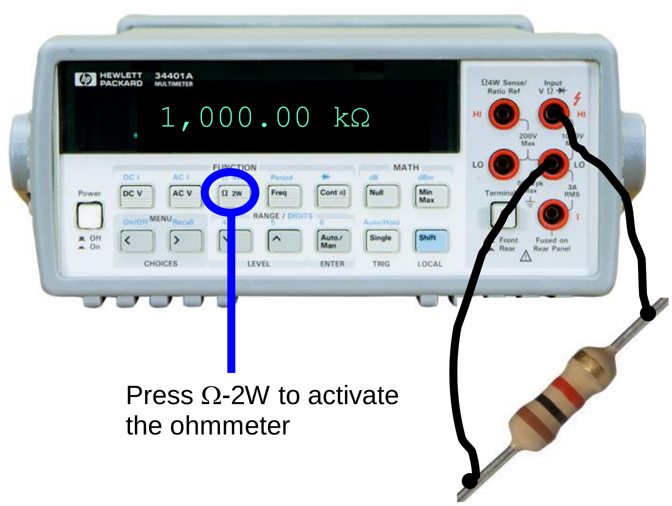
This formula can also be used to express resistance as a ratio of voltage to current: $R = \dfrac{V}{I}$

An *ohmmeter* measures resistance by forcing a small current through a resistor and measuring the resulting voltage. The meter converts the ratio to a resistance value.

Assignment:

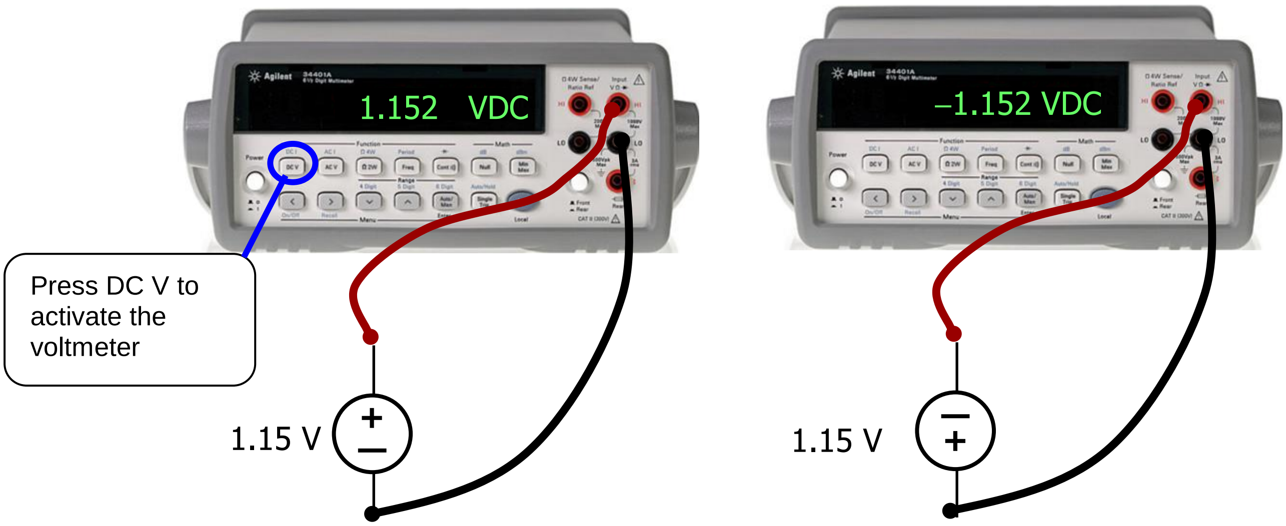
1. Choose **three** resistors of different values from the parts bins in the lab. Determine and record their values from the three-band color code. Next measure their *actual* values (to three significant figures) using your multimeter configured to be an ohmmeter (press the Ω-2W button). Suggested connections are shown below. Note that the polarity of the connection (i.e., HI and LO terminals) not matter when measuring resistors.

Connections for Measuring Resistance



B. Measuring Battery Voltage with a Multimeter

A *voltmeter* measures the voltage appearing between its two input terminals. In our case, the voltage is displayed as being positive when the [+] is connected to the HI terminal, and the [–] to the LO, as shown below:

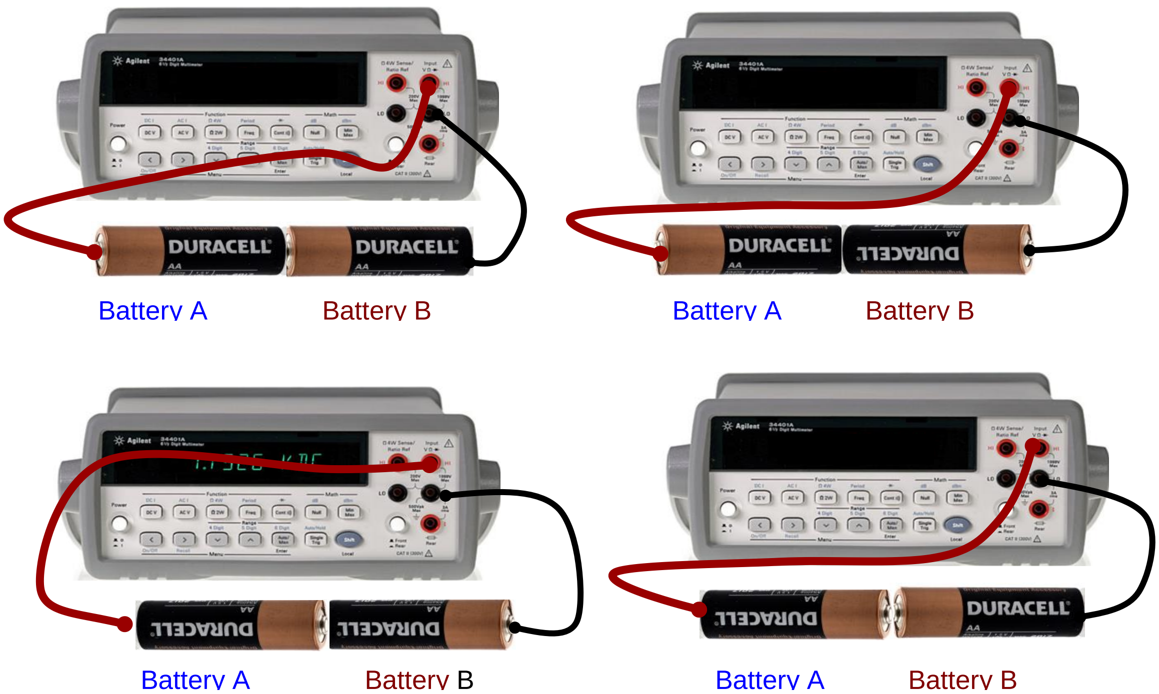


Assignment:

1. Grab two batteries from the parts counter. A fully charged alkaline AA battery has a voltage of *approximately* 1.6 V. Use the multimeter to measure its actual voltage with its polarity connected in both directions, as shown below. (Press the DC button to configure the multimeter as a voltmeter.)

<u>QUESTIONS</u>: Why does the reading change sign when you reverse the battery direction? Is the battery fully charged?

2. Next connect two batteries in each of the four possible configurations shown below. Be prepared to explain to the TA why the four readings differ from each other.



C. Bipolar Power Supplies

In this part of the lab, we learn how to configure the power supply so that it produces *two* voltages relative to a common ground: one positive, and the other negative. This connection is summarized by the circuit diagram shown below (figure C). This form of voltage-source connection will become important when we do experiments with operational amplifiers.

Assignment

1. Connect your supply and the two resistors in the configuration shown in figure C. Be sure to configure both the positive and negative power supplies to read +10 and -10 volts respectively. Measure the voltages between the following sets of nodes, and verify that the circuit performs as expected:

$$V_{A\text{-}GND} \qquad V_{C\text{-}GND} \qquad V_{B\text{-}GND}$$

(For example: $V_{A\text{-}GND}$ means measuring the voltage at node A with respect to ground)

Next we will configure the multimeter to measure current. Until now you measured voltage *across* terminals. Recall that current is a *through variable* and you will have to insert the ammeter in series with the circuit branch you are measuring. The cartoon at the end of the lab illustrates the steps to measure current. Also refer to the section in the appendix called "More About the HP 34401 Digital Multimeter", where it is explained how to measure current before continuing.

2. Use the multimeter to measure the current I_1 flowing through the 10k Ohm resistor to verify that the circuit performs as expected.

3. Now measure the current I_2 flowing through the 1k Ohm resistor to verify that the circuit performs as expected.

4. Measure the current I_3 through the wire connecting the resistors to the COM terminal on the power supply. Explain the value you measured.

Can you explain any differences in your calculated and measured values?

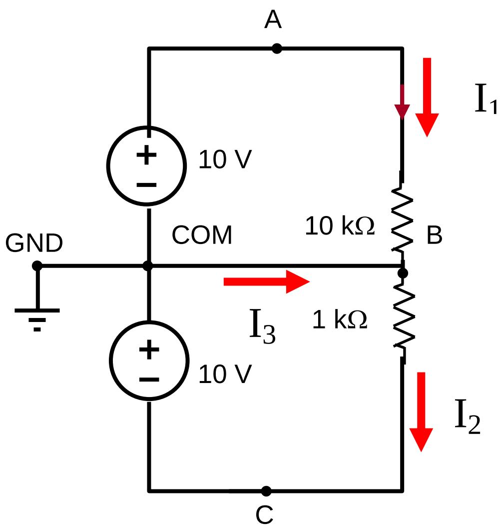
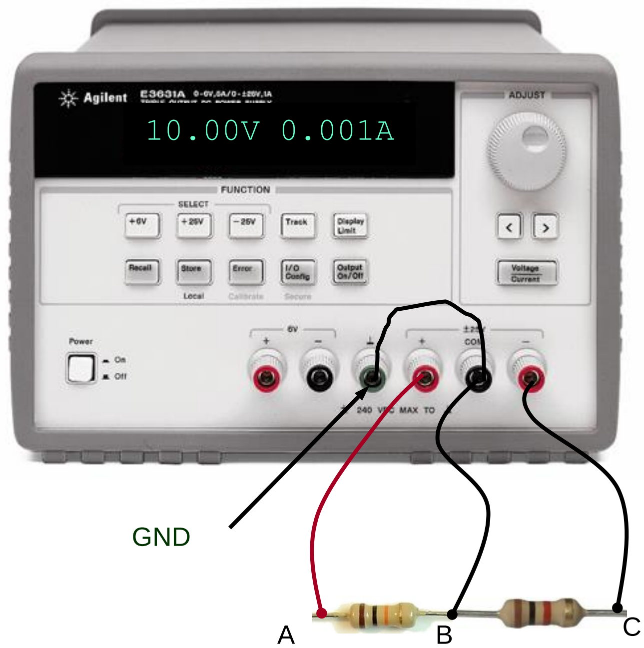
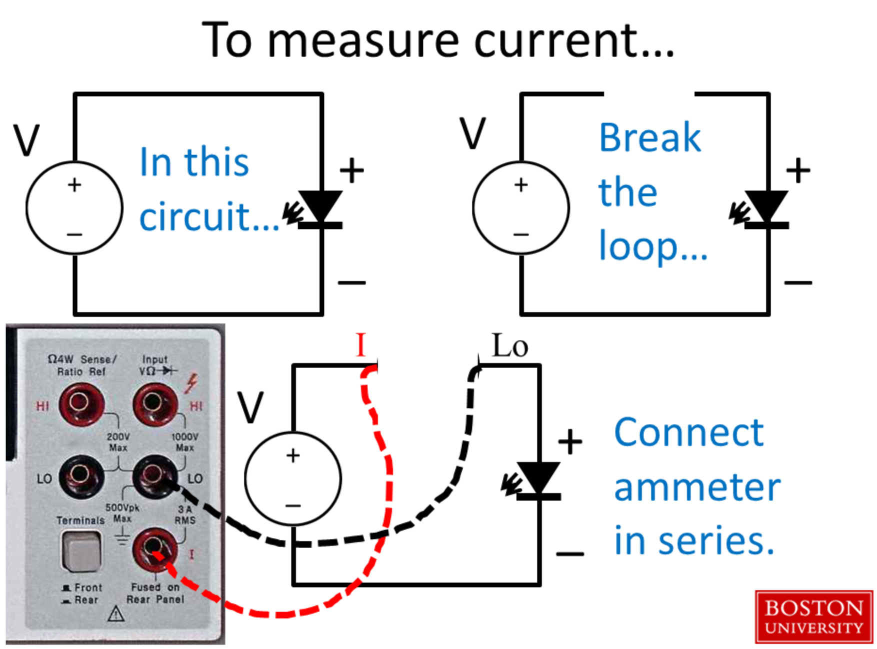


Figure C



Cartoon of the steps to measure the current.

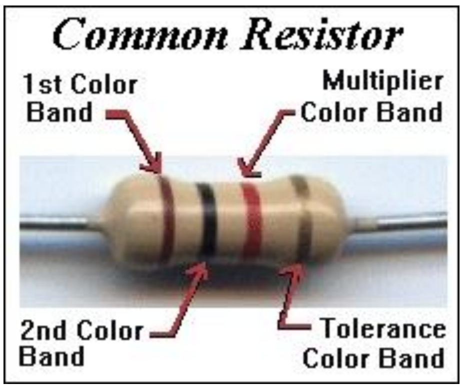


This is the end of the lab! Appendix follows:

Resistor Color Codes:

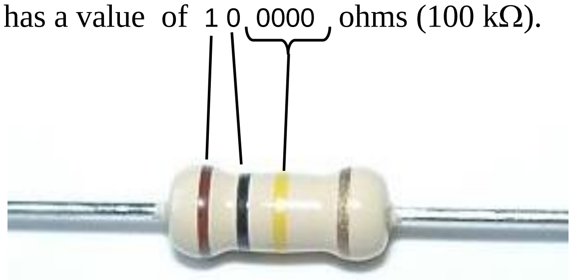
The value and percent tolerance of a common resistor are indicated by a series of colored bands, in which each color represents a digit:

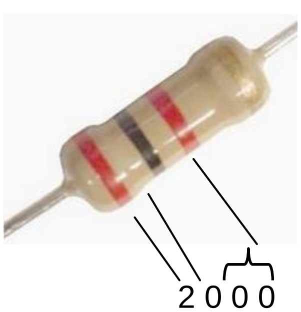
0	1	2	3	4	5	6	7	8	9



To determine the value of a given resistor, position the gold or silver "tolerance band" on the right-hand side, as shown t the left. Next convert the colored bands into three digits. The resistor value is equal to the first two digits, reading from left to right, followed by the number of zeros indicated by third "multiplier" band.

Thus, for example, for the resistor shown below, **Brown** = 1, **Black** = 0, and Yellow = 4, so the resistor has a value of 1 0 0000 ohms (100 kΩ).

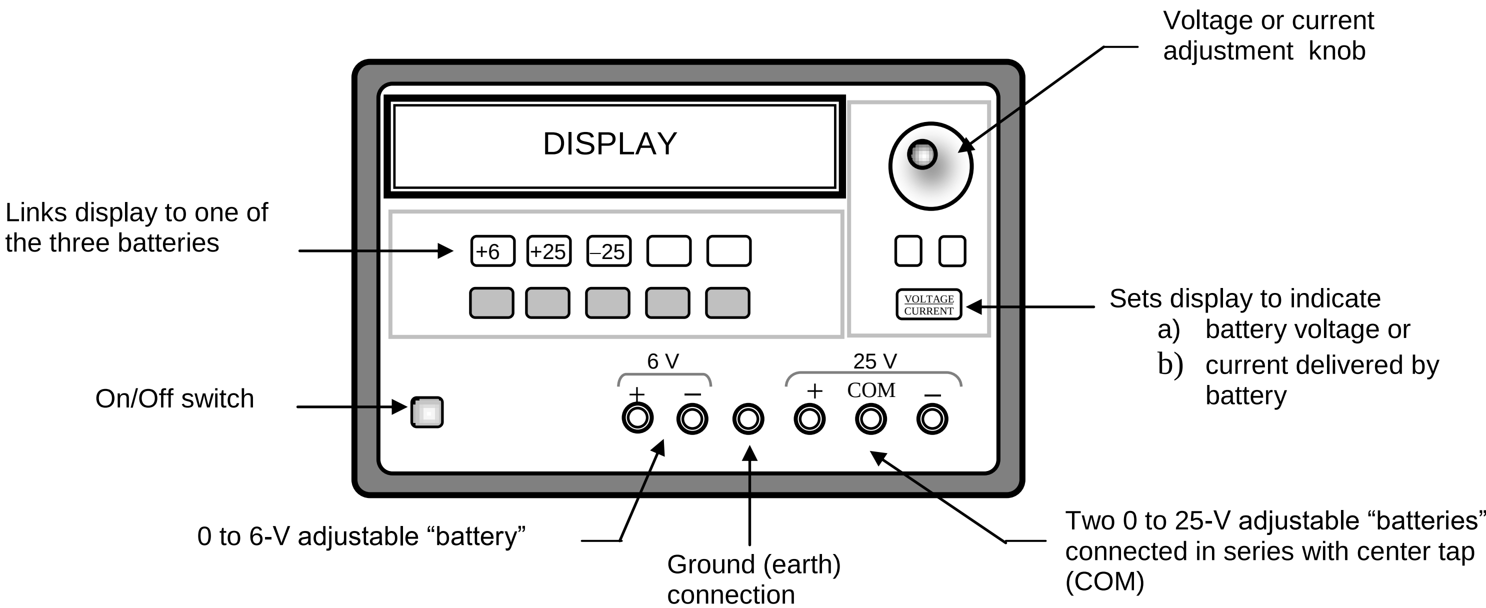




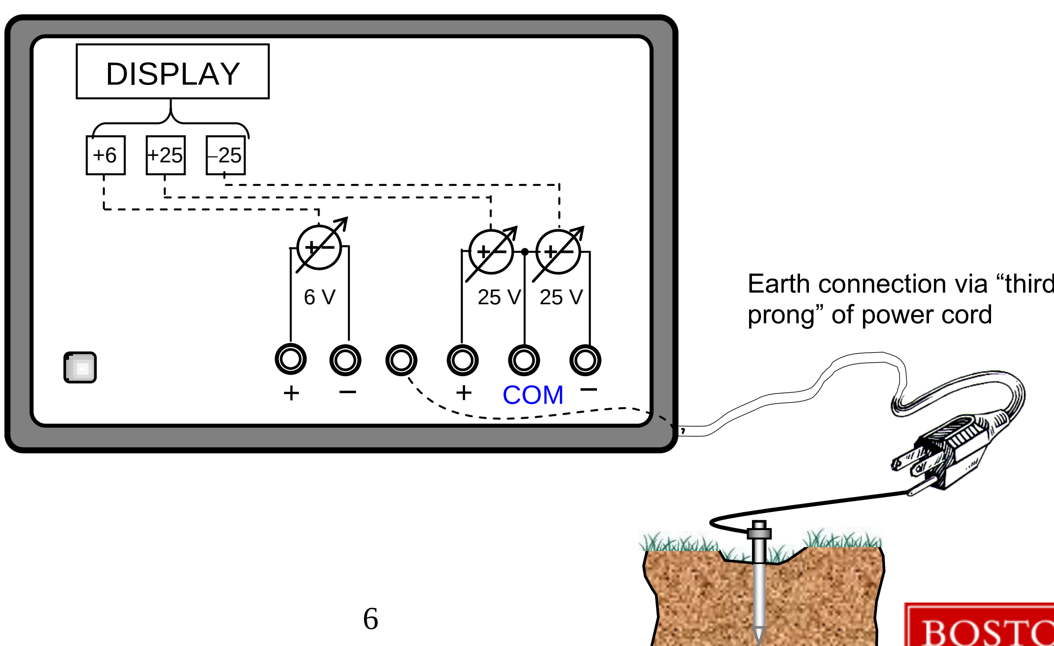
Similarly, the resistor to the left has a value of Red = 2, **Black** = 0, and Red = 2, or 2 0 00 ohms (2 kΩ).

More About the HP 3631A Power Supply

The HP 3631A power supply located on your lab bench is an instrument that simulates, via internal electronics, power available from three separate, adjustable voltage sources. For the purpose of this lab, you may think of these voltage sources as independent batteries whose values you may adjust via the rotation knob in the upper right-hand corner of the instrument. The functions of the various buttons of the supply and the arrangement of the simulated batteries with respect to the connection terminals on the front panel are shown below:

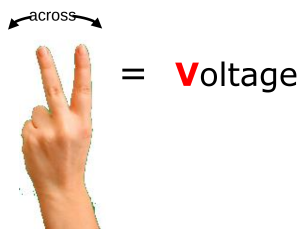


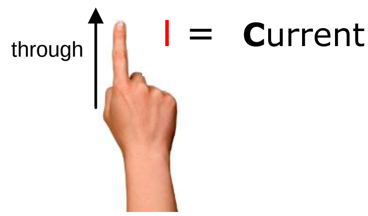
What's Inside



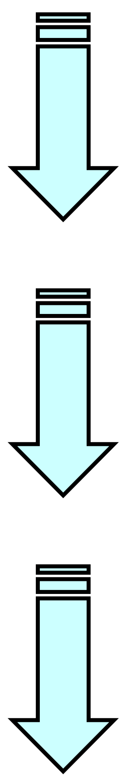
More About the HP 34401 Digital Multimeter

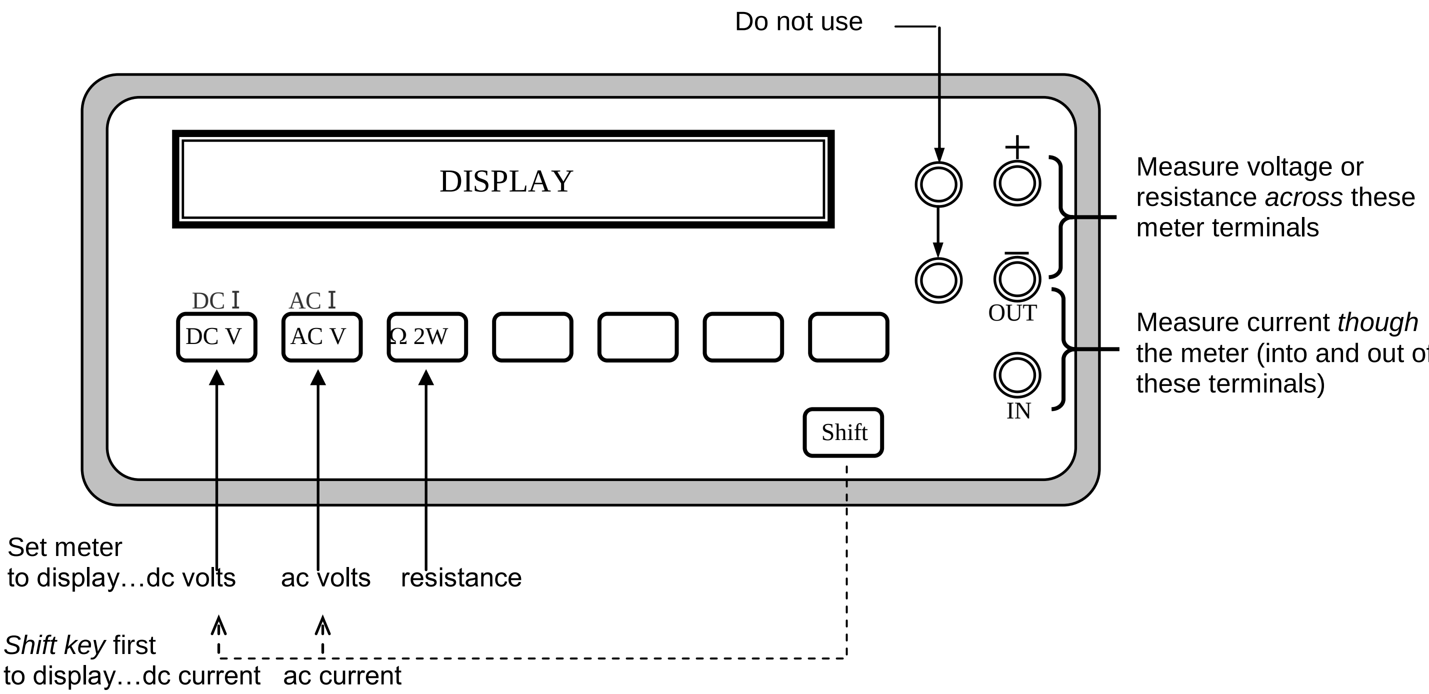
The HP 34401 Digital Multimeter (DMM), shown below, is a very versatile tool. It is capable of taking many types of measurements and it will serve you well if you master its use. Although this DMM is capable of measuring many quantities, we wil l use it solely to measure voltage, current, and resistance. Remember: Voltage is measured *across* two terminals (**V**), i.e. *between* two nodes of a circuit, while current *flows* and must be measured *through* (**I**) a circuit branch.





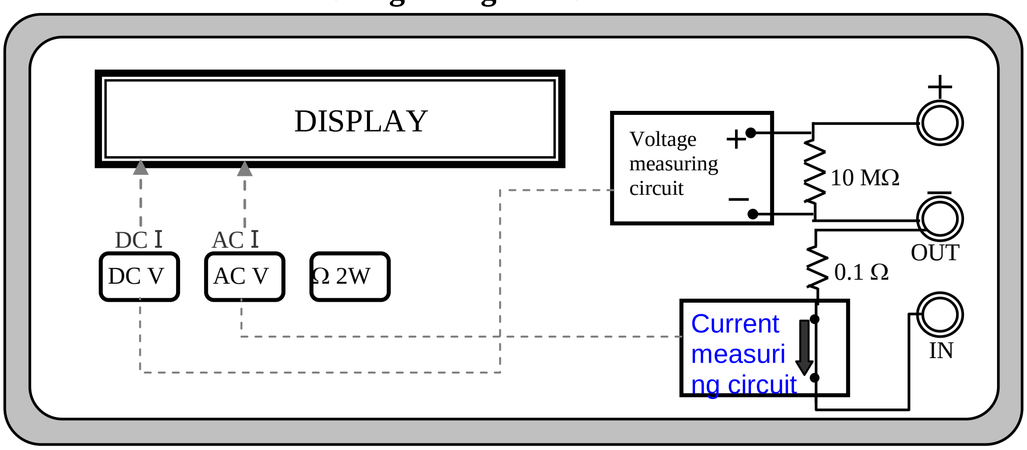
The equivalent internal resistance appearing between the (+) and (–) voltage-measuring terminals is 10 MΩ (mega ohms). The equivalent internal resistance appearing in series with the IN and OUT current-measuring terminals about 5 Ω.





What's inside …

Measuring voltage or current



Measuring resistance